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# RESULTS OF EXPERIMENTS WITH MISCELLANEOUS SUBSTANCES AGAINST THE CHICKEN MITE.[1]

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## INTRODUCTION.

In connection with the enforcement of the insecticide act of 1910 a large number of proprietary insecticides and the ingredients entering into their composition have been tested against the chicken mite. A brief summary of these experiments forms the basis of this bulletin. The work was done at the Insecticide and Fungicide Board's testing laboratory at Vienna, Va., which is under the supervision of Dr. A. L. Quaintance, of the Bureau of Entomology, and under the direct charge of W. S. Abbott.

## THE CHICKEN MITE.[2]

All the tests hereinafter recorded were made against the common red mite of the chicken (*Dermanyssus gallinae* Redi). The mite feeds by sucking the blood of the chickens, attacking them at night while they are roosting. It passes the day under roosts and in crevices elsewhere in the chicken house. Occasionally a few mites are found on the fowls during the day, and sitting hens are liable to attack both day and night. The mite is active in all but the coldest periods of the year and reproduces with great prolificacy. It will live for at least three months without food.

## KINDS OF TESTS MADE, AND METHODS OF ESTIMATING THE RESULTS.

A few tests were made against the mites infesting sitting hens and the nest boxes occupied by them, but the great majority were conducted against mites inhabiting chicken houses, coops, roosts, and nest boxes used by laying hens only.

[1] *Dermanyssus gallinae* Redi.

[2] For an account of the control of the chicken mite the reader is referred to Farmers' Bulletin 801, United States Department of Agriculture, Mites and Lice on Poultry, by F. C. Bishopp and H. P. Wood, and for an account of the bionomics of the chicken mite to Department Bulletin 553, United States Department of Agriculture, The Chicken Mite: Its Life History and Habits, by H. P. Wood.

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The tests included a number of materials and methods grouped under the heading "Miscellaneous treatments," besides special studies of various substances applied in the form of paints, dusts, and sprays. Details of these tests are given under appropriate headings.

In a number of cases substances were tested in small containers, such as jars and vials. Such tests, involving both contact and fumigation action on the mite, were considered so severe that failure to obtain satisfactory results thereby indicated with certainty that the materials would be inefficient in practical use in chicken houses. Such materials might, therefore, be classed as of no value, without further testing.

In computing the degree of efficiency, in tests other than in small containers, it was found necessary to use somewhat arbitrary terms. It is next to impossible to make actual counts of the mites alive and dead on a roost or in a nest box, and much more so in a chicken house. The effect of a material can be gauged only by estimating the general mortality from the percentage of living and dead found in the more easily observed places and by observing how rapidly reinfestation occurs in the premises. In the latter case the season of the year should also be taken into account, as the mite reproduces more rapidly under higher temperatures.

Many materials proved to have no value in the control of mites. Others listed as "inefficient" failed to reduce the mites sufficiently to prevent a speedy reinfestation. In some such cases it appeared that a major percentage of active mites were killed outright, but no effect was exerted on the eggs. Materials to which the term "somewhat efficient" is applied were those in which it appeared that 60 to 75 per cent of the mites were killed, but the residue was large enough to bring about a speedy reinfestation. "Moderately efficient" materials were those which reduced the infestation greatly and prevented more than a comparatively small subsequent reinfestation. The term "efficient" was reserved for materials which killed all or almost all the mites, and subsequent infestation, if any appeared, was insignificant in proportion to the original.

These terms apply only to single treatments. In many cases two or more treatments were made in the same premises. While the total mortality was increased thereby, the treatments were not progressively effective, the subsequent ones not equaling the original in effectiveness. Unless otherwise noted, the tests described herein represent single treatments.

## MISCELLANEOUS TREATMENTS.

### FUMIGATION.

An infested roost was fumigated in a fumigatorium of 360 cubic feet capacity for 6 hours by burning, in sawdust, $8\frac{3}{4}$ ounces of naphthalene. A number of mites were fumigated in a tight container for 30 hours by burning the same quantity in carbon. Both treatments were effective. An infested nest box was treated by burning 13 grams of pyrethrum. A chicken house was fumigated by placing in live coals on the floor 58 cubic centimeters of a preparation containing 7.5 per cent of borax and a small quantity of pyrethrum. Two chicken houses were fumigated by burning respectively 1 and 2 pounds of sulphur for 4 hours. The capacity of the houses used in

these tests was 360 cubic feet, and they were as air-tight as the average chicken house. All the last four treatments were of little or no value.

#### BANDING ROOSTS.

A heavy anthracene oil applied on burlap strips at the ends of clean roosts failed to prevent the access of mites from other places in the chicken house. A few days after the application the oil hardened and the mites were able to cross it. Similar bands made of sticky tree-banding material were also inefficient, even when protection was given from the fowls by placing boards above the sticky portion of the roosts.

#### MEDICATED ROOSTS.

A wooden roost grooved beneath so as to fit tightly to a tin trough running the whole length of the roost and containing a coal-tar and mineral-oil mixture, when placed in an infested chicken house, repelled the mites as long as the trough contained oil to keep the wooden roosts permeated. This roost had no effect on the mites in other parts of the house (e. g., the nest boxes).

#### SUBSTANCES IN FOOD AND WATER OF FOWLS.

The preparations following were all without value when added to the food and water of fowls: Two lime-sulphur preparations, each containing less than 12 per cent of calcium polysulphids and calcium thiosulphates diluted at the rate of 1 to 2,150 and added to food and water for 5 and 13 days, respectively; three preparations containing from 33 to 35 per cent of free sulphur, added to each quart of food at the rate of 1 heaping teaspoonful three times a week for 6 weeks; and one preparation containing 38 per cent of free sulphur with a trace of naphthalene, used as in the preceding test but for 4 weeks only.

#### REPELLENT SUBSTANCES SUSPENDED IN INFESTED PREMISES.

A preparation consisting of naphthalene 14 per cent, carbon disulphid 46 per cent, and mineral oil 40 per cent, contained in a bottle with a wick, suspended from the roof of a chicken house for 2 weeks, was without value. Fifteen grams of pyrethrum (ground flowers) was suspended in a cloth bag from the top of an infested nest box. This also was of no value.

#### NEST EGGS, NESTING HAIRS, AND NESTING MATERIALS.

Prepared nest eggs, which are primarily designed to protect sitting hens and remain in use during the period of incubation, were used in infested nest boxes only, to determine whether they would be efficient in killing or expelling the mites.

Eight tests were made with eggs of pure naphthalene. In no case was any efficiency shown. These eggs remained in the nests for periods as long as 25 days. Their use in some instances caused marked injury to the fowls sitting on them and appeared to interfere with the health of the embryo chicks alongside them.

Five tests were made with eggs of naphthalene and paraffin mixed. These eggs were used in five infested nests for 2 hours on each of 3 days, at intervals varying from 6 to 8 days. None of these treatments was of value.

An egg containing 5 per cent of naphthalene and a small quantity of formaldehyde was used for 19 days without any effect.

A plaster egg containing a tin receptacle holding a mixture of naphthalene and sawdust was charged weekly with a mixture composed of turpentine 54 per cent, formaldehyde 18 per cent, and water 28 per cent. This egg was used for 4 weeks without any effect.

Two kinds of prepared nesting hair (fats 9.4 and 3.8 per cent, respectively) were placed in infested jars for 8 days. These proved valueless.

Two tests were made with nesting materials of shredded bark and crumbled leaves of cedar. This material was placed in clean nest boxes in mite-infested premises, and sitting hens were employed. In both cases mite infestation developed.

#### TREATMENT OF THE HEN.

Six hens were treated by rubbing into the skin 1 inch below the vent a preparation containing 5.6 per cent of mercury. The fowls were kept for 16 days in an infested chicken house. At the end of that time the house was still infested.

#### CONCLUSIONS REGARDING MISCELLANEOUS TREATMENTS.

Of the miscellaneous methods listed above only two indicated any efficiency—naphthalene fumigation and the medicated roosts.

The tests with the former were made in a fumigatorium under optimum fumigating conditions. This method would be of value where nest boxes, coops, or roosts were to be treated, but an infested house could not be treated unless very nearly air-tight. The fact that sulphur burnt at the rate of over 6 pounds to 1,000 cubic feet was quite inefficient in a chicken house at least as nearly air-tight as the average house precludes satisfactory fumigation under usual conditions.

The medicated roost was of some value, since it afforded protection to roosting fowls for a long time, but unless the rest of the premises are treated no protection is afforded fowls on the nest.

### DUSTS.

In the dusting tests various makes of hand dusters were used.

The following dusts were without value under natural conditions: Air-slaked lime, Paris green, hellebore, calcium fluorid, sodium fluorid, sodium silico fluorid, barium fluorid, barium tetrasulphid, mercuric chlorid, and sulphur (refined and commercial). With the exception of calcium fluorid and mercuric chlorid none of these substances was efficient even in jar tests.

#### TOBACCO.

Tobacco dusts containing nicotine up to 5.26 per cent (the strongest percentage tested) were inefficient.

#### PHENOLS.

Dusts containing phenols up to 2 per cent were inefficient.

### NAPHTHALENE.

Since naphthalene was efficient as a fumigant, it appeared that this material might have effect as a dust. Naphthalene of 40-mesh fineness was dusted in nest boxes at 100 per cent, 75 per cent, 50 per cent, and 23 per cent strengths.

In the first of these tests it was efficient, in the second and third (with wheat flour as diluent) moderately so, and in the last (with sand as diluent) inefficient. Pure naphthalene dusted on roosts was efficient in two out of four tests. A 4 per cent naphthalene in lime was inefficient in a roost test, while a 12 per cent preparation in sulphur and lime proved moderately efficient when dusted in an infested coop. Coarse naphthalene was inefficient when dusted in two infested chicken houses, while a naphthalene of 40-mesh fineness was of slight value in a third.

It appeared that naphthalene is efficient only in a small circumscribed area where it may have a fumigation effect. In more open places it has a rather weak repellent effect. Dissolved in kerosene, the mixture was not more efficient than pure kerosene, but dissolved in gasoline the resultant mixture was more efficient than pure gasoline.

In practice, dusting with naphthalene is not a feasible method for the control of the chicken mite.

### DERRIS.

Four infested chicken houses were dusted with the finely ground powder of the roots of *Derris* sp. Undiluted dust was efficient in one house and temporarily so in another. In a third house a 75 per cent dust was only moderately efficient, in a fourth test a 50 per cent dust was inefficient. Flour was used as a diluent.

Derris powder is a remedy of value, but it would appear that two or more applications are necessary and that it loses its efficiency if diluted more than 25 per cent. Its action on larvæ and adult mites is first to stupefy them, the insects dropping to the ground and dying after two or three days. The material is rather unpleasant to apply.

### PYRETHRUM.

Finely ground flowers of *Pyrethrum cinerariaefolium* and *P. roseum* were efficient when dusted undiluted in a nest box and when applied in a chicken house in two applications 33 days apart. Another house was dusted once and a third twice (32 days between applications). These latter tests showed only moderate efficiency, but conditions were very unfavorable in the house treated twice.

Pyrethrum diluted with flour to 75 and 50 per cent strengths was inefficient in chicken houses.

Pyrethrum is somewhat less efficient and less unpleasant to handle than derris-root powder.

### SABADILLA SEEDS.

Finely ground sabadilla seeds (*Schoenocaulon officinale*) were efficient in treating an infested nest box.

It appears probable that this material equals derris in efficiency, but no chicken house tests were made to determine this point.

### CONCLUSIONS REGARDING DUSTS.

From the foregoing it appears that of the dusts derris powder is the most efficient, that pyrethrum is of much value, that naphthalene is efficient only in circumscribed areas where a good fumigation effect can be obtained, and that ground sabadilla seeds may prove efficient but require more thorough testing.

## PAINTS.

Various preparations and substances have been tested as paints, applied with a brush. A dust consisting of naphthalene 23 per cent, phenols 0.6 per cent, coal-tar hydrocarbon oils 1 per cent, tobacco dust, and siliceous material was inefficient when mixed with water to form a thick paint and applied on an infested nest box. A preparation containing coal-tar creosote oil 87 per cent (the remainder being water) was efficient when painted over the entire inside of a chicken house. Anthracene oil alone and also at the rate of 1 pound to a gallon of turpentine killed mites on roosts. Cresol in whitewash in a roost treatment was efficient at 5 per cent, but not at 2.5 per cent. Whitewash alone was inefficient.

All efficient contact sprays are of value when applied as paints if the infested premises do not contain deep cracks (which harbor the mites) into which the liquid can not be forced with a paint brush as successfully as by the spray nozzle. While roosts can be painted without much trouble, it is more satisfactory to spray nest boxes, coops, and chicken houses.

## SPRAYS.

In the tests with sprays the liquids were applied with a knapsack sprayer holding approximately 5 gallons, and a Bordeaux type of nozzle was used in most instances. In some cases where roosts or coops were treated a hand sprayer was used.

### SOLUTIONS OTHER THAN OILS.

Spray tests with solutions other than oils are summarized in Table 1. Some of the materials contained animal oils (whale oil), but none mineral oils.

TABLE 1.—*Results of spray materials (other than oils) against the chicken mite.*

| Material. | Dilution in water. | Subject of test. | Results. |
|---|---|---|---|
| *Per cent.* | | | |
| Ammonia water ..... 28.00 | 1 to 9 ..... | Roost ..... | Inefficient. |
| Alcohol, ethyl ..... 95.00 | None ..... | Roost and coop ..... | Do. |
| Formaldehyde ..... 37.50 | 1 to 9 ..... | Chicken house, coop... | Somewhat efficient. |
| Ferric sulphate [$Fe_2(SO_4)_3$] 42.34 | 1 to 9, 3 to 7 ..... | Roosts, nest boxes..... | Inefficient. |
| Sodium hypochlorite .... [1].94 | None ..... | Nest boxes ..... | Do. |
| Sodium sulphur ..... 13.87 | 1 to 16 ..... | Coops ..... | Do. |
| Do ..... 12.45 | 1 to 8, 1 to 5 ..... | Roosts ..... | Do. |
| Lime-sulphur (32° B.).... 34.00 | 1 to 15, 1 to 9 ..... | Chicken houses, nests.. | Do. |
| Nicotine sulphate [2] ..... 41.82 | 1 to 600 ..... | Chicken houses ..... | Somewhat efficient. |
| Do [2] ..... 8.72 | 1 to 75 ..... | .....do ..... | Moderately efficient. |
| Derris extract [2] ..... 16.00 | 1 to 1,000, 1 to 500 ..... | .....do ..... | Inefficient. |
| Whale-oil soap ..... 80.00 | 1 lb. to 1 gal ..... | .....do ..... | Somewhat efficient. |
| Do ..... 80.00 | 2 lbs. to 1 gal ..... | .....do ..... | Do. |

[1] "Available chlorine."
[2] Whale-oil soap at the rate of 4 pounds to 100 gallons of water added.

Table 1 indicates that several well-known contact insecticides used at strengths ordinarily efficient against most sucking and some chewing insects proved inefficient against the chicken mite.

In a number of tests, sodium hypochlorite at a dilution weaker than 0.94 per cent ("available chlorine") was in all cases inefficient.

Formaldehyde, 4 per cent, did not give a killing that could be termed efficient and was objectionable to the operators.

Lime-sulphur and sodium sulphur, well-known acaricides, proved inefficient, the former even at dormant orchard strength.

Free nicotine at a strength of 0.07 per cent in combination with whale-oil soap, 4 pounds to 100 gallons, proved but slightly efficient, while at a strength of 0.12 per cent with a similar proportion of whale-oil soap it was moderately efficient.

Extract of derris, 16 per cent, diluted to 1 to 1,000 and 1 to 500, with the addition of whale-oil soap, 4 pounds per 100 gallons, was inefficient.

Whale-oil soap, 1 pound to 1 gallon and at twice this strength, showed some efficiency but was hardly satisfactory.

### OILS.

Tests were made with three types of oil preparations: (1) Straight oils, (2) mechanical mixtures of two oils or solutions of another type of substance (e. g., naphthalene) in an oil, and (3) oil emulsions.

Preparations of the first type included kerosene, gasoline, and coal-tar creosote oil. Pure kerosene was used in three chicken houses. In one house it was efficient; in the two others only moderately so. Gasoline was of little value. A coal-tar creosote oil (sp. gr. 1.062 at 30° C.) was quite efficient. It appears certain that all the heavier oils, undiluted, would be efficient, but the lighter oils, perhaps owing to too rapid evaporation, are less efficient.

The tests made with mechanical mixtures are given in Table 2.

TABLE 2.—*Results of tests with oil mixtures and mixed oils against the chicken mite.*

| No. of test. | Materials. | Strength. | Dilution.[1] | Result. |
|---|---|---|---|---|
| | | *Per cent.* | | |
| 1 | Paradichlorobenzene | 100.0 | 960 grams in kerosene 4 gallons | Moderately efficient. |
| 2 | do | 100.0 | 480 grams in kerosene 4½ gallons | Somewhat efficient. |
| 3 | do | 100.0 | 960 grams in gasoline 4½ gallons | Inefficient. |
| 4 | Naphthalene | 100.0 | 960 grams in kerosene 5 gallons | Somewhat efficient. |
| 5 | do | 100.0 | 480 grams in kerosene 4 gallons | Do. |
| 6 | do | 100.0 | 240 grams in gasoline 2 gallons | Do. |
| 7 | Wood creosote oil | 100.0 | 1 to 8 in whitewash | Efficient. |
| 8 | Phenol | 100.0 | do | Moderately efficient. |
| 9 | Crude carbolic acid | 100.0 | 1 to 9 in whitewash | Efficient. |
| 10 | do | 100.0 | 1 to 11½ and 1 to 15 in whitewash | Inefficient. |
| 11 | Cresol<br>Kerosene | 20.0<br>80.0 | None | Efficient. |
| 12 | Coal-tar creosote oils<br>Phenols | 86.8<br>13.2 | do | Do. |
| 13 | Carbolineum<br>Kerosene | 50.0<br>50.0 | do | Do. |
| 14 | Carbolineum<br>Kerosene | 33.3<br>66.7 | do | Do. |
| 15 | Carbolineum<br>Kerosene | 25.0<br>75.0 | do | Do. |
| 16 | Carbolineum<br>Kerosene | 20.0<br>80.0 | do | Do. |
| 17 | Carbolineum<br>Kerosene | 10.0<br>90.0 | do | Do. |
| 18 | Carbolineum<br>Kerosene | 7.0<br>93.0 | do | Somewhat efficient. |

[1] In tests 1 to 6, inclusive, the paradichlorobenzene and the naphthalene were dissolved in the oils.

Paradichlorobenzene dissolved in kerosene and gasoline, and naphthalene dissolved in kerosene, gave no better results than the respective oils by themselves. Naphthalene dissolved in gasoline was more efficient than gasoline itself. The use of paradichlorobenzene is not advisable, as it was found to impart a taste to eggs laid after the treatment of the chicken house.

Mechanically mixed in whitewash and applied immediately, wood creosote oil was efficient when the oil comprised 11 per cent of the spray. Crude carbolic acid in whitewash was efficient at 10 per cent and inefficient at 8 per cent. Phenol was moderately efficient in whitewash at 11 per cent.

The other tests reported in Table 2 were with mixed oils. They demonstrated the efficiency of heavy tar oils. The coal-tar oil (carbolineum) used in tests 13 to 18, inclusive, had a specific gravity of almost 1.2. Such an oil evaporates much more slowly than a mineral oil of the type of kerosene.

Oils were used in the form of emulsions also. These are divisible into three types—emulsions of light mineral oil, heavy mineral oil, and coal-tar oils. In some of the second class a small quantity of coal-tar oil had been added.

Table 3 presents the tests made with oil emulsions against the chicken mite.

TABLE 3.—*Results of tests with oil emulsions against the chicken mite.*

| Test No. | Nature of oil. | Composition of emulsion. | | | | | Dilution. | Result. |
|---|---|---|---|---|---|---|---|---|
| | | Oil. | Soap. | Phenols. | Water. | Undetermined, by difference. | | |
| | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | | |
| 1 | Light mineral | 77.0 | 4.0 | ..... | 18.6 | 0.4 | 1 to 3 | Efficient. |
| 2 | .....do | 77.0 | 4.0 | ..... | 18.6 | .4 | 1 to 7 | Inefficient. |
| 3 | Heavy mineral | 82.2 | 8.0 | ..... | 6.9 | 2.9 | 1 to 2.5 | Efficient. |
| 4 | .....do | 82.2 | 8.0 | ..... | 6.9 | 2.9 | 1 to 4 | Moderately efficient. |
| 5 | .....do | 82.2 | 8.0 | ..... | 6.9 | 2.9 | 1 to 6 | Inefficient. |
| 6 | .....do | 84.1 | 7.5 | ..... | 7.3 | 1.1 | 1 to 16 | Do. |
| 7 | .....do | 84.1 | 7.5 | ..... | 7.3 | 1.1 | 1 to 24 | Do. |
| 8 | .....do | 79.6 | 5.9 | 6.9 | 7.6 | ..... | 1 to 4 | Somewhat efficient. |
| 9 | .....do | 82.7 | 5.0 | 5.9 | 6.4 | ..... | 1 to 9 | Inefficient. |
| 10 | .....do | 82.6 | 4.2 | ..... | 13.2 | ..... | 1 to 3 | Efficient. |
| 11 | .....do | 82.6 | 4.2 | ..... | 13.2 | ..... | 1 to 4 | Do. |
| 12 | Coal-tar | 30.4 | 24.6 | 40.0 | 5.0 | ..... | 1 to 157 | Inefficient. |
| 13 | .....do | 41.0 | 22.0 | 30.0 | 5.0 | 2.0 | 1 to 32 | Somewhat efficient. |
| 14 | .....do | 41.0 | 22.0 | 30.0 | 5.0 | 2.0 | 1 to 99 | Inefficient. |
| [1] 15 | .....do | 48.0 | 25.6 | 12.0 | 14.4 | ..... | 1 to 49 | Moderately efficient. |
| [1] 16 | .....do | 50.0 | 22.0 | 16.0 | 8.0 | 4.0 | 1 to 24 | Efficient. |
| 17 | .....do | 63.9 | 21.9 | 7.5 | 6.7 | ..... | 1 to 12.3 | Moderately efficient. |
| 18 | .....do | 63.9 | 21.9 | 7.5 | 6.7 | ..... | 1 to 19 | Do. |
| 19 | .....do | [2] 3.2 | 1.0 | [2] | ..... | [3] 95.8 | 2 pounds to 1 gallon. | Inefficient. |

[1] Box tests.
[2] Coal-tar oils and phenols 3.2 per cent.
[3] Sand and mineral pigment 95.8 per cent.

The oil used in tests 1 and 2 was kerosene. The emulsion was efficient when diluted 1 to 3 parts water.

In tests 3 to 11 the material contained a heavy mineral oil with high boiling point, and in addition a small amount of coal-tar oil was present in that used in tests 6 to 9, inclusive.

These oils were efficient when used at dilutions of 1 to 2.5 and 1 to 3 parts water.

Coal-tar oils were used in tests 12 to 18, inclusive. In tests 15 and 16 nest boxes were used and a dilution of 1 to 24 was efficient. In tests with chicken houses an emulsion of somewhat greater oil content was only moderately efficient when diluted 1 to 12.3 parts water.

The material used in the last test was a powder containing 3.2 per cent oils and phenols and 1 per cent soap. It was diluted as little as 2 pounds to a gallon of water. At this and all weaker strengths it was inefficient.

## SUMMARY.

*Miscellaneous treatments.*—Miscellaneous treatments for the chicken mite included fumigating infested premises, banding roosts, using a medicated roost, adding substances to the food and water of fowls, placing prepared nest eggs under sitting hens, using medicated nest hairs and nesting materials, hanging up substances in infested premises, and treating hens with an ointment.

Only two of these treatments were of any value. A medicated roost remained free from mites, but the rest of the chicken house continued infested. Naphthalene burned in sawdust and carbon was efficient when used in a fumigatorium. Fumigation of chicken houses does not appear to be satisfactory. In a chicken house of average air-tightness, sulphur burned at the rate of 6 pounds to 1,000 cubic feet was inefficient.

*Dust.*—Materials without value in the form of dusts were calcium fluorid, sodium fluorid, sodium silico-fluorid, barium fluorid, barium tetrasulphid, mercuric chlorid, Paris green, hellebore, refined and commercial sulphur, and air-slaked lime. Used in tobacco dust, nicotine up to 5.26 per cent was inefficient, and so also were phenols up to 2 per cent in a dust carrier. Powdered derris root and pyrethrum flowers were efficient when undiluted. Naphthalene was efficient only in the case of nest boxes and not in chicken houses. Tests with powdered sabadilla seeds were insufficient. This material gives promise of high efficiency.

*Paints.*—Tests with materials applied as paints indicated that heavy oils, either pure or slightly diluted with lighter oils, were efficient. Cresol 5 and 10 per cent in a whitewash was of some value. A stiff whitewash alone was inefficient, as was a preparation containing 23 per cent naphthalene.

It is not so easy to penetrate to deep cracks with a paint brush as with a spray nozzle, and therefore painting houses with deep cracks is not as effective as spraying.

*Sprays.*—The following materials when applied as sprays to infested premises were inefficient or without value: Ammonia water, 2.8 per cent; ethyl alcohol; formaldehyde, 4 per cent; iron sulphate, 15.88 per cent; lime-sulphur (32° Baumé), 1 to 9; sodium sulphur (12.45 per cent sodium sulphid and thiosulphate), 1 to 5; sodium hypochlorite, 0.94 per cent "available chlorine"; extract of derris root, 1 to 500.

Nicotine solutions containing 0.07 per cent and 0.12 per cent free nicotine, with the addition of whale-oil soap at the rate of 4 pounds to 100 gallons, were of some value, especially the stronger solution. Whale-oil soap at 1 pound to a gallon and at 2 pounds to a gallon was also of some value.

Pure, heavy coal-tar creosote oil was entirely efficient. Kerosene was moderately efficient and under some conditions quite so, but it lacked the body and lasting effect of the heavier oils. Gasoline was of little value.

Paradichlorobenzene and naphthalene when dissolved in kerosene and gasoline were not more efficient than the pure oils themselves, except that naphthalene in gasoline gave results somewhat superior to pure gasoline.

In a whitewash, 11 per cent of creosote oil and 10 per cent of crude carbolic acid were efficient, but 8 per cent of the latter was of no value and 11 per cent of phenol was only moderately efficient. These mixtures are wholly mechanical and must be applied immediately. They are less satisfactory than emulsions or combinations of oils.

Oil mixtures of kerosene and cresol and of kerosene and carbolineum were quite efficient even when the coal-tar oils comprised only 10 per cent of the mixture. A preparation of 20 per cent of the heavier oil would insure more body to the material; in fact, the higher the percentage of heavy oil the more lasting will be the effect.

Kerosene-oil emulsion containing 77 per cent of oil was efficient when diluted 1 to 3 or 25 per cent. This gives an oil percentage in the spray of 19.25 per cent. Greater dilutions were less efficient, but two or more applications of a spray containing not less than 16 per cent of oil should be of considerable value.

Emulsions of heavy mineral oils containing approximately 82 per cent of oil were efficient at strengths of 1 to 2.5 and 1 to 3 in water, the actual sprays containing, respectively, 23.49 and 20.65 per cent of oil. Out of two tests in which the oil content of the sprays was 16.5 and 16.4 per cent, respectively, one spray was efficient and the other moderately so. Sprays with less than 16 per cent of oil were inefficient, but two applications at this strength would be of much value.

Chicken-house tests with coal-tar disinfectants were made with sprays containing as much as 4.8 per cent of oil. At this strength a single application was moderately effective. In nest boxes as little as 2 per cent of oil was efficient.

Kerosene-oil emulsion diluted to 19.25 per cent oil appeared superior to pure kerosene, perhaps because of its greater penetrating power. Emulsions of coal-tar oil diluted to 4.8 per cent oil were inferior to straight tar oils and to mixtures of coal-tar and mineral oils.

## RECOMMENDATIONS.

Heavy oils from coal tar and wood tar, or such oils diluted with a lighter oil, such as kerosene, so that not less than 20 per cent of the mixture is heavy oil, will successfully control chicken mites, provided the premises are thoroughly sprayed and the material not stinted.

A heavy mineral-oil emulsion containing at least 20 per cent oil in the actual spray will be efficient under similar conditions.

## ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

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